DIVISION OF COMPUTER SCIENCE

Education for Flexibility: Transferable Skills, Problem Solving and Information Management

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Abstract

In this paper we describe a problem solving course which has been devised and run in the school of Information Sciences at the University of Hertfordshire. The course aims to teach Computer Science degree students a range of transferable skills that can be applied both within and beyond their chosen discipline. Our current students will be professionals during a period of massive change. As Engel (1991) points out, for such students self-directed learning is likely to be a necessity. They will need skills in communication, critical reasoning, problem solving, decision making, self-management and self-evaluation. It is these skills, together with the domain specific knowledge acquired from other courses on the Computer Science degree, that will enable the students to meet professional demands in a rapidly changing world.

Key words: problem solving, transferable skills, domain specific knowledge.

Introduction

The majority of graduates in all academic disciplines leave university with a sound knowledge of their specific domain of interest and embark on a career in which they feel this knowledge will be useful and relevant. It is increasingly the case, however, that promotion and success in the workplace will involve taking on some kind of managerial role. Headmasters do little teaching; senior nurses spend most of their time in administration; the most highly paid jobs in industry are predominately those of managers. Domain specific knowledge alone is inadequate to ensure a successful and satisfying career.

In the school of Information Sciences at the University of Hertfordshire we are addressing this problem through a course in the theory and practice of problem solving. The course has been devised not only to cover problem solving in Information Science, but also to abstract out common skills and techniques that can be transfered across different problem domains.

Transferable skills

"Problem solving is the fundamental activity of people working in science and engineering." (Rine and Bhagava, 1992). The discipline of problem solving involves a range of skills which could be useful in many different problem domains. These transferable skills include general techniques and approaches to solving problems, written and oral communication skills, and many management skills, such as planning, monitoring and controlling activities and the ability to understand and manage group situations. The stated objectives of the Problem Solving Course in the School of Information Sciences at Hertfordshire include the following:

On completion of the course, the student will, at an appropriate level, be able to:

- Identify sensible boundaries for simple problems.
- Analyse situations to extract a precise formulation of a problem.

- Utilise a variety of techniques for expressing problems and their solutions.
- Utilise a variety of techniques for planning, monitoring and controlling the management of the problem solving process.
- Discuss the group and cognitive factors that facilitate and inhibit problem solving and their applications in general problem solving and management of the problem solving process.
- Participate fully, and constructively, in team problem solving.
- Elicit and model user requirements for simple systems by applying appropriate communication skills and modelling techniques.
- Show an awareness of the existence of alternative strategies for the management of the problem solving process, and discuss, at an appropriate level, the assumptions upon which these are based.

The course also addresses the need for domain specific knowledge in problem solving and introduces a range of methods and tools used in the development of information systems.

Style of the course

Our current students will be confronted with rapidly changing professional demands. They will need to develop skills in self-directed learning, communication, critical reasoning, problem solving, decision making, self management and self evaluation. To meet these needs, a problem solving course should be student centred and activity based. Our students are encouraged to enhance their problem solving abilities through analysis and discussion of their performance on a range of problems and through subsequent goal setting for future problems. They are encouraged to develop a profile of their strengths and weaknesses in problem solving and to use this profile as a focus for setting their learning objectives. Initially course activities are taken from familiar everyday domains, gradually as the course and students' understanding progresses, these activities become more oriented toward particular areas of interest. In our course this entails the development and management of computer science problems, in particular those relating to information systems.

The problem solving reference model

From the very beginning of the course all the students are encouraged to build up their own problem solving reference model. This model is constructed from the students' experience of and observations on solving a variety of problems. Throughout the course, the reference model is applied, tested and gradually refined. (This pattern of learning corresponds to Kolb's (1984) experiential learning cycle).

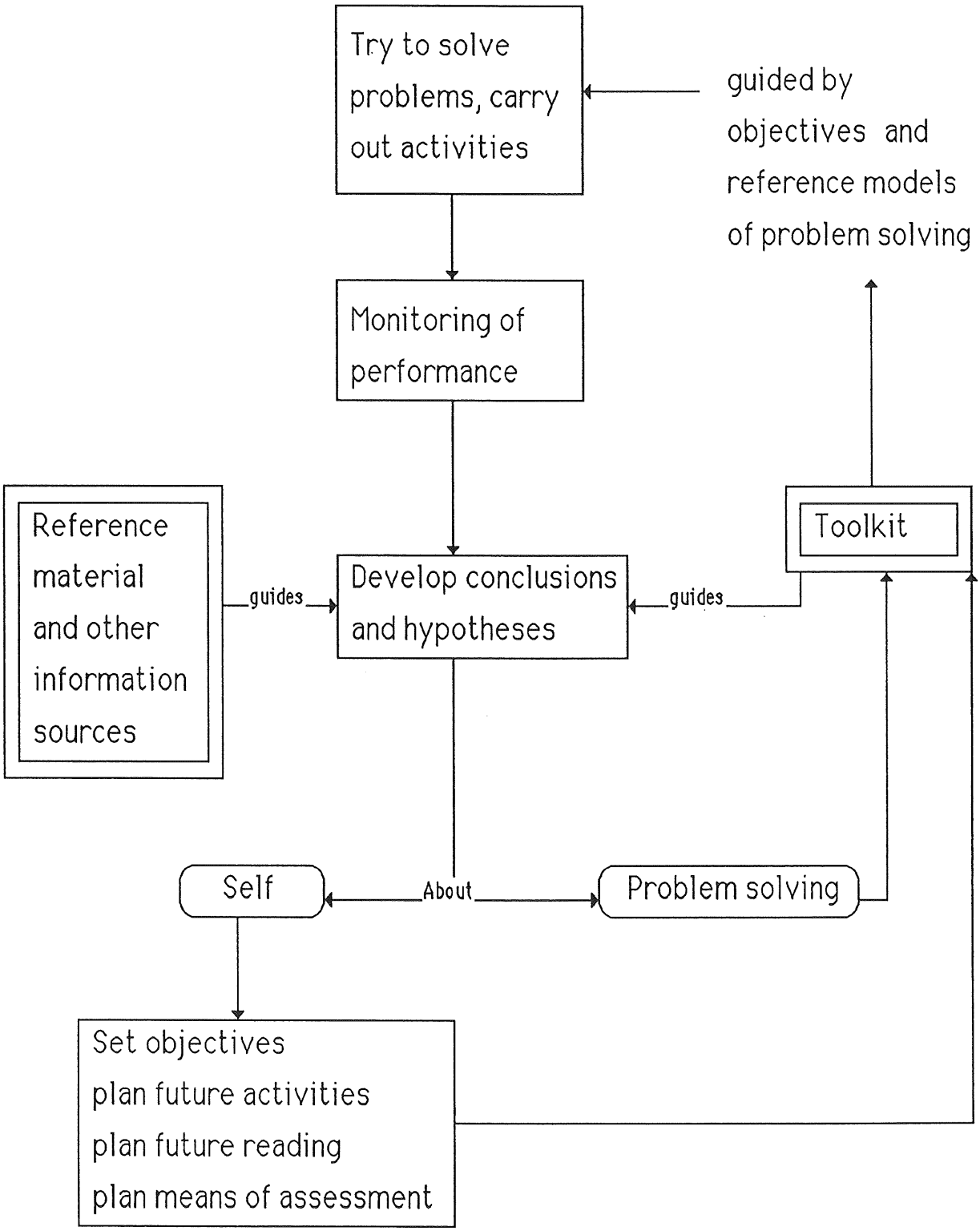
One of the aims of the course is to enable the students to build-up useful problem solving knowledge abstractions. Gick and Holyoak (1983) see the formation of such problem solving schemata as occuring through the successful mapping of one problem solution onto another. We seek to draw students' attention to similarities between problems and to enable students to generalise their learning, by striving to develop their own abstractions. The problem solving reference model acts as a focus for these abstractions. An important step in enabling the students to build their own problem solving reference model is to provide a broad framework for their abstractions. One such framework, that we make available to students, is Bransford and Stein's (1984) Ideal problem solving model.

From the start of the course , then, the students are introduced to the concept of a problem solving reference model. This is seen as a set of concepts and techniques that will support them in their problem solving activities. The model includes such varied concepts as problem perception, information gathering, problem representation, domain specific knowledge, hypothesis testing , problem management and group dynamics. Sudents are encouraged to see the problem solving course as an opportunity for building and refining their own individual problem solving reference models. At the same time, however, it is stressed that the model is only an aid to managing their activities and should never become the driving force of the student's problem solving. The model can be seen rather as a check list or prompt, reminding the problem solver of some relevant point which he or she may have temporarily forgotten.

The structure of the course

The main body of the course consists of a mixture of student centred activities , directed reading, mini-projects, students presentations, report writing, self-assessment exercises, brief lectures, discussion and feedback.

An activity centred session typically follows the pattern described by the figure and notes below.



- Problem solving activity . This is usually carried out in groups and involves some kind of observation, either by the problem solvers themselves or by an external observer.

- Monitoring of performance. This takes the form of a feedback session and general discussion. Questions covered may include:
  What have we learned from this activity?
  How can we usefully apply this knowledge?
  How well did we manage the problem solving process?
  What goals could we set for future problem solving activities?
  What implications are there for our problem solving model?
  What is the relevance of this to Computer Science?

- Develop conclusions and hypotheses. Students are always expected to write up their account of the activity and the following discussions. Students reports should be based not only on their experience of the problem solving activity, but also on relevant reference material and other sources of information.
  The conclusions and hypotheses drawn from the activity, discussion and report all contribute to the enhancement of the student's own problem solving ability and his or her toolkit of relevant techniques and skills.

- On the basis of what has been learnt form the process, the students are encouraged to set their own objectives for problem solving, to plan their activities and reading, and to consider how all this can be assessed, monitored and controlled. In this way, the students are gradually taught to manage their own problem solving.

As previously stated these steps can be seen as an implementation of Kolb's (1984) model of experiential learning.

Features of the course

Group dynamics.

All activities on the problem solving course are carried out in groups, usually made up of between three and four students. The composition of the groups is changed for each activity, so that the students do not get used to working with a particular team of people. They constantly have to adapt to new group situations. The importance of group work, both in Computer Science and in management, is stressed throughout the course and individual groups are monitored by staff during activities to identify any problems.

The role of observation.

It is important that students should be able to observe and report on group problem solving behaviours. They should also be able to listen to and take on board observation of their own behaviours. This is one of the main means we have of focusing students' attention on particular types of behaviour in problem solving. Almost all of the course activities involve some form of observation. While the activity is being carried out, observation may be by appointing a member of each group to act as an external observer, or by means of interrupting the activity so that the students can record precisely what they were doing at that moment. After the activity is over, retrospective self-observation is promoted during discussion and feedback sessions. The students are also expected to show an awareness of their own problem solving behaviour in their written reports. These kinds of observation act as forcing functions (Norman 1991), to some extent disrupting students' asutomatic problem solving behaviour and forcing them to pay attention to the way they habitually deal with problems. Awareness of habitual behaviour is the begining of change.

A wide range of problem activities.

Getting students to transfer their learning to other situations is often difficult. We encourage students to do this by setting a variety of activities where students look at problems in their own lives or on other courses and then present an analysis of them. Problems which the students are set during the course cover a wide range of activities: from library research to code breaking and from

project planning to designing a new traffic scheme for the university. Many researchers (eg. Tulving et al. 1964, Morton 1964, Meyer 1975, all in the area of word recognition) have emphasised the importance of context as a memory retrieval cue. By providing a multiplicity of problem solving contexts we provide a rich set of cues to the students' abstract knowledge of problem solving. Two examples of problems that have been set during the course can be found in the appendices to this paper.

Assessment

One of the aims of the problem solving course is to encourage students to provide their own assessment, both by peer assessment and by self-monitoring and evaluation.It was decided early on that a traditional examination would not be appropriate for the course, so formal assessment of the students is based on different types of coursework, such as the problem solving reports and a substantial essay relating the student's problem solving reference model to activities carried out on the course. Detailed assessment is not easy with the large numbers of students that we have to deal with, but we do try to provide frequent opportunities for feedback, both during activities and by meeting small groups of students to discuss particular problems. We also constantly encourage students to provide their own feedback and to set their own goals in terms of their individual progress.

Self management

A large number of the students expect and want passive learning. This is an enduring and persistent mind set that our students seem to have. They expect to attend lectures and to receive detailed feedback on their progress. They do not expect to have to manage their own learning and find their own feedback. Yet this is our ultimate target. We approach this goal, gradually, trying to show them the value of autonomous learning and self-evaluation. We also encourage students to plan, monitor and control their own route through the problem solving course. The problem solving reference model provides essential support and guidance while the students are learning to do this.

Conclusion

The problem solving course has been designed to meet clear educational needs. It has been built on sound educational and psychological theory. The design and running of the course has presented us with a serious challenge, which we feel we have met. The effect of the course on students' problem solving and management skills is hard to measure objectively, although attitude surveys have yielded moderately favourable results. Three extreme comments from students illustrate how they have been affected by the problem solving course:

"I found this course a little too slow and a little too woolly to sustain my interest. I realise that the woolliness and "find out for yourself" aspects were deliberate in order not to say "this is the way its done" but feel that the cons of this method outweighed the pros"

"One of the things I've learned is that I can't bear criticism"
"Have you got any better at this?"
"No, but at least I know that I can't bear criticism now."

"I feel much more in charge of my work now. I am able to set goals for myself, and even if I don't reach them, I can find out why and do something about it."

It is very hard for students to realise how much they have changed during the running of a course. As observers we have found quite striking changes in students' approach to problem solving, to group situations , to management and in their ability to communicate. The course has now been running for three years and the first intake are at present working in industry. A marked improvement has been seen in the students' ability to cope with new situations and unexpected problems. We are confident that further positive effects of the course will become apparent when the students ultimately graduate and find employment.

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Appendix 1: Sample problem

Managing a project

This activity is to be carried out in groups of three or four people. One member of each group will act as external observer and keep a record of problem solving activities during the project.

1 Your task is to write a program to add two numbers together in a computer language or package which is new to you.

2 Draw up a list of sensible tasks for this project and estimate how long each task will take you.

3 Make a list of the resources you will need for the project and establish when they will be available.

4 Determine the order in which you will perform the tasks and see if it is possible for any to be carried out in parallel.

5 Carry out the project, modifying your original plans where necessary.

6 Write a report on how the project was managed. You should think about the following questions:

- How well was the problem defined? Did any parts of it need further clarification? How did you achieve this?
- Did you identify useful tasks and sub-tasks?
- How accurate were your estimates ?
- To what extent were you able to stick to your original plan?
- How closely did the observer's records match what the other team members felt about the project?
- Did working in a group make the project easier or more difficult?

Tutor's Notes

Timing and organisation:

Students should tackle the problem in groups of three or four. One member of each group should be appointed as observer.

This problem activity can be set one week to be completed by the following week. This allows students to find out when resources, such as computers and manuals, are free, and to plan their work accordingly.

Aspects of the problem solving reference model covered by this activity:

Problem definition and boundary, planning, estimating, scheduling resources, testing, group phenomena,written presentation skills.

Appendix 2 : Sample problem

The University Traffic Problem

There are a number of problems with traffic at the University. It can be hard to find parking space, traffic flow is somewhat congested and there have even been a few accidents. You have two hours to consider the problem and devise a single solution that you will be able to justify to your peers.Within the boundaries of the Law, University regulations and the conventions of normal politeness you can use any materials you can find within the University Campus. Your solution should consist of:

1. A list of proposed changes and a map showing the changes.
2. A justification of each change balancing the cost (financial, efficiency of other activities, social etc.) of the change against the benefits you expect it to bring.

Within each group one of you will be an observer who will carry out observations at 15 minute intervals, recording the activity in which each member of the group is involved. The observer should also record the reasons for this behaviour and what the group was hoping to achieve. Column headings should be:: Time of observation, Person, Activity Description ,Purpose.

At the end of 2 hours there will be a general discussion.

On your return:

1. Each group should sum up their solution in one sentence and this will be written on the board.

2. Each group should then consider the following questions and produce agreed written answers to be handed in at the end of the session.

- Briefly what are the pros and cons of each idea?

- How do you rank the solutions and what are your criteria for the ranking?

- What factors, activities and behaviours led you to your solution? For those factors, activities and behaviours with a negative influence consider how you could have got round them.

The report on this problem solving activity should include the following:

This problem sheet
Specific problem addressed by the group: reasons for choosing this specific problem
Observation record
Your complete design solution as in 1 and 2 above
Notes on the concluding discussion of the problem and what this tells us about problem solving.

Tutor's Notes

Timing and organisation:

Students should tackle the problem in groups of four or five.They should be given the problem sheet. One member of each group should be appointed as observer.They must all be clear about which room to come back to, when, and what to bring with them.

Aspects of the problem solving reference model covered by this activity:

Problem definition and boundary, information gathering, modelling a problem, manipulating a model to produce a solution, difficulties of testing, group phenomena,written presentation skills.